Active Project (2014 - 2017)

Avionics and Software Project

Advanced Exploration Systems Program | Human Exploration And Operations Mission Directorate (HEOMD)

ABSTRACT

The goal of the AES Avionics and Software (A&S) project is to develop a reference avionics and software architecture that is based on standards and that can be scaled and customized. The architecture will contain basic core elements and functionality needed for any spacecraft. The goal for specific mission implementation is that the avionics will be 80% core Avionics and Software elements and 20% unique.

This project incorporates and builds on the results from the AES Avionics Architecture for Exploration and the Core Flight Software projects.

ANTICIPATED BENEFITS

To NASA funded missions:

Reduced cost and time of avionics system implementation.

Increased reconfigurability of spacecraft systems to increase the probability of mission success.

To NASA unfunded & planned missions:

Reduced cost and time of avionics system implementation.

Increased reconfigurability of spacecraft systems to increase the probability of mission success.

To other government agencies:

If used, could provide reduced cost and time of avionics system implementation.

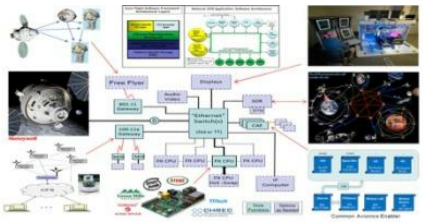
To the commercial space industry:

If used, could provide reduced cost and time of avionics system implementation.

To the nation:

Reduced cost and time of avionics system implementation.

Increased reconfigurability of spacecraft systems to increase the



Baseline Avionics and Software Architecture

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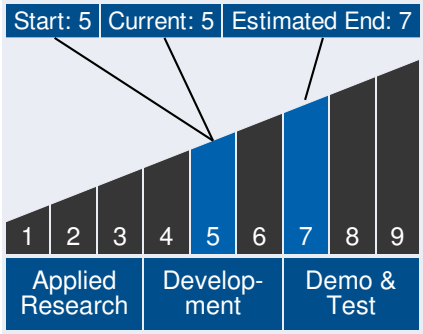
Technology Maturity



Management Team

Program Director:

- Jason Crusan

Program Executive:

- Richard Mcginnis

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probability of human mission success.

DETAILED DESCRIPTION

The A&S project will also focus on the affordability and maintainability of avionics systems. The project will take into account design, development, test, and evaluation (DDT&E) costs, maintenance costs, upgrade flexibility, size, weight, and power (SWaP).

The following architecture guidelines will be followed:

- Minimize SWaP for Avionics in Flight Vehicle
  - Use wireless where possible
  - Minimize wire weight
  - Use low/no power sensors
  - Pick a topology that keeps the processors close to what they control
- Minimize Cost
  - Use existing capabilities to avoid near-term DDT&E
  - Allow for growth using new technology to avoid future DDT&E
  - Allow for infusion of new technology to reduce sustaining
  - Leverage commercial technology development efforts as applicable
- Minimize Risk (multi-faceted)
  - Use proven technology for critical functions
  - Use existing capabilities to minimize schedule risk
- NASA should develop and own the Reference Architecture
  - Develop a reference implementation, utilizing existing standards when possible, of the architecture that can be provided to industry as a basis for standards

The A&S project will build on the progress made by two previous AES projects: the Avionics Architectures for Exploration project and the Core Flight Software (CFS) project. The work accomplished under these previous AES Projects has resulted in a core avionics architecture for future exploration vehicles.

Management Team *(cont.)*

Project Manager:
- James Ratliff

Technology Areas

Primary Technology Area:
Human Health, Life Support, and Habitation Systems (TA 6)
- Extravehicular Activity Systems (TA 6.2)
  - Power, Avionics, and Software (TA 6.2.3)
    - Battery Package (TA 6.2.3.1)

Modeling, Simulation, Information Technology and Processing (TA 11)
- Computing (TA 11.1)
  - Flight Computing (TA 11.1.1)

Robotics and Autonomous Systems (TA 4)
- Systems Engineering (TA 4.7)

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Key elements of this architecture, shown in the Figure: Baseline Avionics Architecture, are:

- The use of Ethernet as a backbone data bus. Time Triggered Ethernet (TTE) is included in order to accommodate any deterministic data requirements. It has been shown that standard Ethernet and TTE can co-exist on the same data bus
- Use of existing IEEE 802.11 communications standards for proximity communications
- Use of ISA100.11a communications standards for wireless instrumentation systems, which will serve to reduce the weight and complexity of point-to-point wiring.
- The use of Core Flight Software, certified for human spacecraft applications in FY14, which will support reusability and commonality of software applications.
- Development of a catalog of processors that can be used for Low-Earth orbit (LEO), Cis-Lunar, and deep-space applications
- Development of a bus translator (Common Avionics Enabler) to convert different network standards to Ethernet.
- Advances in Human Interface systems to enable improved Astronaut interactions with future space vehicles

The Avionics and Software Project team will develop a system level environment and architecture that will accommodate equipment from multiple vendors in order to benchmark performance for missions beyond low Earth orbit (LEO). This will allow NASA to take advantage of strides being made by industry to drive our development and reduce sustaining costs. The project team will also evaluate emerging technologies in industry and academia to ensure that other potentially beneficial concepts are not overlooked.

The reference architecture will be developed by dividing it into four core areas: Command and Data Handling (C&DH), Wireless and Communications, Human Interfaces, and Software. The hardware selected for these core areas will typically be mid/high TRL and currently available. The hardware must also have

Technology Areas *(cont.)*

Nanotechnology (TA 10)
- Energy Storage, Power Generation, and Power Distribution (TA 10.2)
  - Power Distribution (TA 10.2.3)
    - Carbon Nanotube Based Power and Avionics Cables (TA 10.2.3.1)
- Sensors, Electronics, and Devices (TA 10.4)
  - Nanoelectronics (TA 10.4.2)
    - Nanoelectronics Based Adaptive Logic (TA 10.4.2.2)

Ground and Launch Systems (TA 13)
- Operational Life-Cycle (TA 13.1)
  - Autonomous Command and Control for Integrated Vehicle and Ground Systems (TA 13.1.3)
    - Automated Fault Detection and Isolation Systems (TA 13.1.3.5)

lineage that gives the team confidence that a radiation tolerant version that can survive the environment beyond Earth orbit and will be available within a reasonable time.

The C&DH Team will focus on the areas of processors and single board computers, network architecture and hardware, instrumentation systems, and hardware/network standards. They will demonstrate the use of multiple operating systems such as VxWorks, Integrity, Xenomai, and RTEMS, all utilizing Core Flight Software on the host processor. Also, they will address radiation tolerance issues with higher performance processors which are required to support the demands of human exploration. Various network technologies will be investigated for critical and non-critical applications.

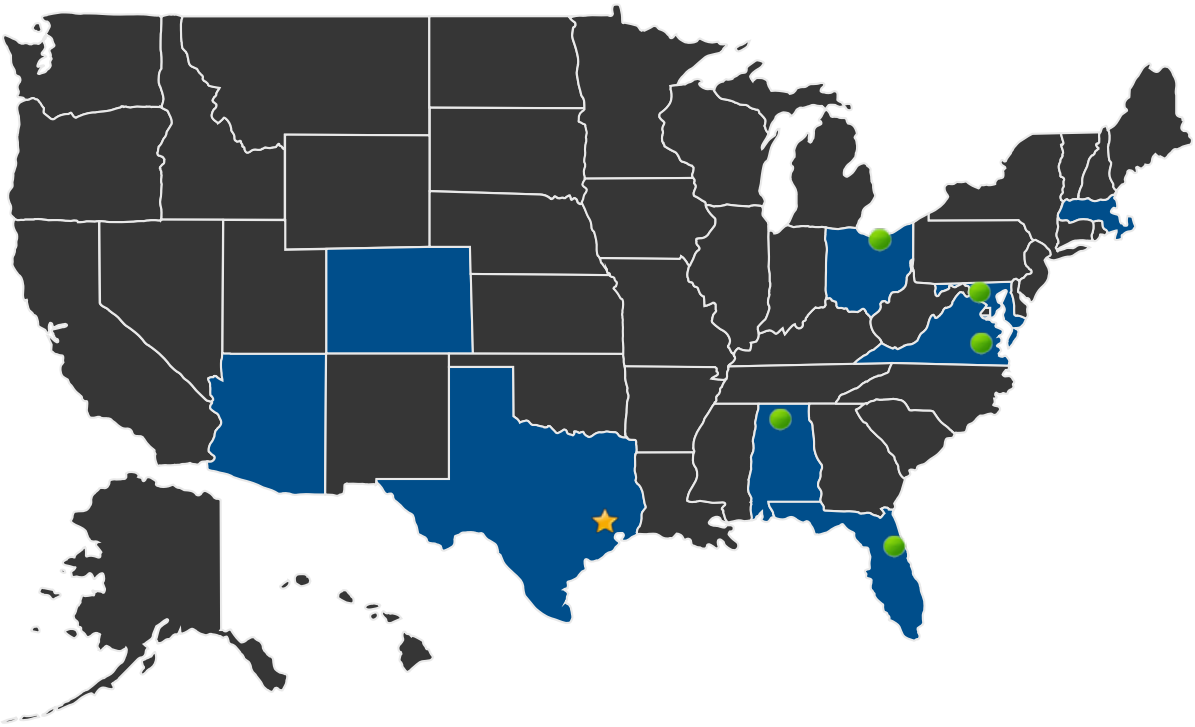
The Wireless and Communications Team will focus on developing a communications architecture that will operate over multiple mission phases and across various users, including international and commercial partners. They will take into account communications amongst several vehicles, EVA, and the ground while incorporating Delay/Disruption Tolerant Networking (DTN) technology to enable internetworking in the presence of long delays and frequent disruptions. The team will consider systems that support multiple formats, reconfigurability, adaptive power control, and other cognitive capabilities. The system will also have to address the high data rate demands of human exploration. The communications team will evaluate existing communications hardware from industry, including existing commercial and international standards. The team will also support ongoing standardization efforts for new technology as applicable, to help address the needs for space applications.

The Human Interfaces Team will address the great challenge of providing displays, audio systems, video systems, and controls which will reliably function in the environment beyond low Earth orbit, where new operational concepts will be needed due to communication delays. They will evaluate new display technologies (such as OLEDs) and Graphics Processing Unit options (including a software GPU). Off the shelf video and audio systems will be evaluated for performance, integration within the architecture, and environmental concerns.

The Software team will continue the development of CFS with a specific focus in human-rated systems. A Johnson Space Center Engineering Directorate Internal Research and Development (IR&D) project initially seeded analysis and prototyping into the applicability of CFS toward human rated systems. This effort was augmented in June 2012 under AES funding specifically targeted to utilize the Orion platform as a target architecture supporting a concept mission to the Earth-Moon L2 point. The work in FY12 resulted in a key conclusion confirming viability of the CFS architecture to adapt to both inter-machine and intra-machine fault tolerance. The work prototyped and demonstrated the CFS system running both within the ARINC-653 standard allowing intra-machine software partitioning as well as on a software-voting triplex platform allowing inter-machine

redundancy. Reusability of applications on these differing architectures was confirmed by running identical cFE applications and GNC applications on both platforms, for only a relatively small development effort for specific platform adaptation.

U.S. WORK LOCATIONS AND KEY PARTNERS



U.S. States With Work

Lead Center:
Johnson Space Center

Supporting Centers:

- Glenn Research Center
- Goddard Space Flight Center
- Kennedy Space Center
- Langley Research Center
- Marshall Space Flight Center

Contributing Partners:

- Ball Aerospace & Technologies
- Honeywell, Inc.
- Jacobs Engineering
- The Charles Stark Draper Laboratory, Inc.

DETAILS FOR TECHNOLOGY 1

Technology Title

Avionics and Software

Technology Description

This technology is categorized as a hardware system for manned spaceflight

The A&S project is developing an architecture for human space flight avionics systems and a catalog of hardware suitable for use in space. This includes development of computer hardware to advance the processing power availalbe for space missions.

Capabilities Provided

A common architecture for avionics will decrease cost of mission system design and provide common system components to increase the ability for reconfiguration of components to increase likelihood of mission success.

A catalog of hardware that is suitable for use in space will decrease the cost of mission systems' design.

Increasing the in-space computational power available for human spaceflight missions will allow greater on-board mission support.

Potential Applications

This is intended to be used on human space flight systems but it could be used for any space flight system that wanted to use it.